GRDA

YOUR PUBLIC POWER TEAM

March 27, 2000

Mr. William Grimley
Emissions Measurement Center
Interstate 40 and Page Road
4930 Old Page road
Room Number E-108
Durham, North Carolina 27709
Att: Electric Utility Steam Generating Unit
Mercury Test Program

Subject: GRDA Unit #2, Speciated Mercury Emissions Testing Reports

Dear Mr. Grimley:

Enclosed please find three copies of the subject test reports for the Speciated Mercury Emissions Tests, which were performed on GRDA Unit #2 at the request of your agency. The tests were performed and the reports generated by Mostardi-Platt Associates, Inc. of Elmhurst, Illinois.

If you should have any questions or need further information, please contact Doug Vore at (918) 476-5840 or dvore@grda.com.

Sincerely,
Grand River Dam Authority

Ron Coker
General Manager/ CEO

xc: wo/attach. Chris Cariker, KAMO
Robert Sullivan Jr., GRDA
Charles Barney, GRDA
Bob Jett, GRDA
Doug Vore, GRDA
Perry Friedrich, GRDA

☑ ADMINISTRATION
PO Box 409
Vinita OK 74301
918-256-5545
918-256-5289 Fax

☐ COAL-FIRED COMPLEX
PO Box 609
Chouteau OK 74337
918-476-5840
918-476-8270 Fax

☐ CUSHING FIELD OFFICE
PO Box 329
Cushing OK 74023
918-225-1507

☐ ENERGY CONTROL CENTER / KERR DAM
PO Box 772
Locust Grove OK 74352
918-479-5249
918-825-1935 Fax

☐ ENVIRONMENTAL & SAFETY
PO Box 10
Chouteau OK 74337
918-476-8268
918-476-8306 Fax

☐ LAKE PATROL
PO Box 70
Langley OK 74350
918-782-9594
918-782-4723 Fax

☐ PENSACOLA DAM
PO Box 70
Langley OK 74350
918-782-3382 also Fax

☐ SALINA PUMPED STORAGE PROJECT
PO Box 609
Salina OK 74365
918-434-5920 also Fax

☐ TRANSMISSION & ENGINEERING
PO Box 1128
Pryor OK 74362
918-825-0280 also Fax

SPECIATED MERCURY EMISSIONS TESTING

Performed For
GRAND RIVER DAM AUTHORITY

On
Unit No. 2
FGD System Inlet and Stack
Chouteau, Oklahoma

September 22, 1999

Mostardi Platt

Mostardi-Platt Associates, Inc.
A Full-Service
Environmental Consulting
Company

945 Oaklawn Avenue
Elmhurst, Illinois 60126-1012
Phone 630-993-9000
Facsimile 630-993-9017

Mostardi Platt

SPECIATED MERCURY EMISSIONS TESTING
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FGD System Inlet and Stack
Chouteau, Oklahoma
September 22, 1999

MOSTARDI PLATT PROJECT 93803
DATE SUBMITTED: MARCH 13, 2000

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CERTIFICATION SHEET

Having supervised and worked on the test program described in this report, and having written this report, I hereby certify the data, information, and results in this report to be accurate and true according to the methods and procedures used.

Data collected under the supervision of others is included in this report and is presumed to have been gathered in accordance with recognized standards.

MOSTARDI-PLATT ASSOCIATES, INC.

James R. Platt
Vice President, Emissions Services

Reviewed by:

Frank H. Jarke
Manager, Analytical and Quality Assurance

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1.0 INTRODUCTION

1.1 Summary of Test Program

The United States Environmental Protection Agency (USEPA), is using its authority under section 114 of the Clean Air Act, as amended, to require that selected coal-fired utility steam generating units provide certain information that will allow the USEPA to calculate the annual mercury emissions from each unit. This information will assist the USEPA Administrator in determining whether it is appropriate and necessary to regulate emissions of Hazardous Air Pollutants (HAPs) from electric utility steam generating units. The Emission Measurement Branch (EMB) of the Office of Air Quality Planning and Standards (OAQPS) oversees the emission measurement activities. MOSTARDI-PLATT ASSOCIATES, INC. (Mostardi Platt) conducted the mercury emission measurements.

The USEPA selected the Unit No. 2 of Grand River Dam Authority in Chouteau, Oklahoma to be one of seventy-eight coal-fired utility steam generating units to conduct mercury emissions measurements. Testing was performed at Unit No. 2 on September 22, 1999, and was the only tested unit at this facility. Simultaneous measurements were conducted at the FGD System Inlet and Outlet Stack. Mercury emissions were speciated into elemental, oxidized and particle-bound mercury using the Ontario-Hydro test method. Fuel samples were also collected concurrently with Ontario-Hydro samples in order to determine fuel mercury content.

1.2 Key Personnel

The key personnel who coordinated the test program and their telephone numbers are:

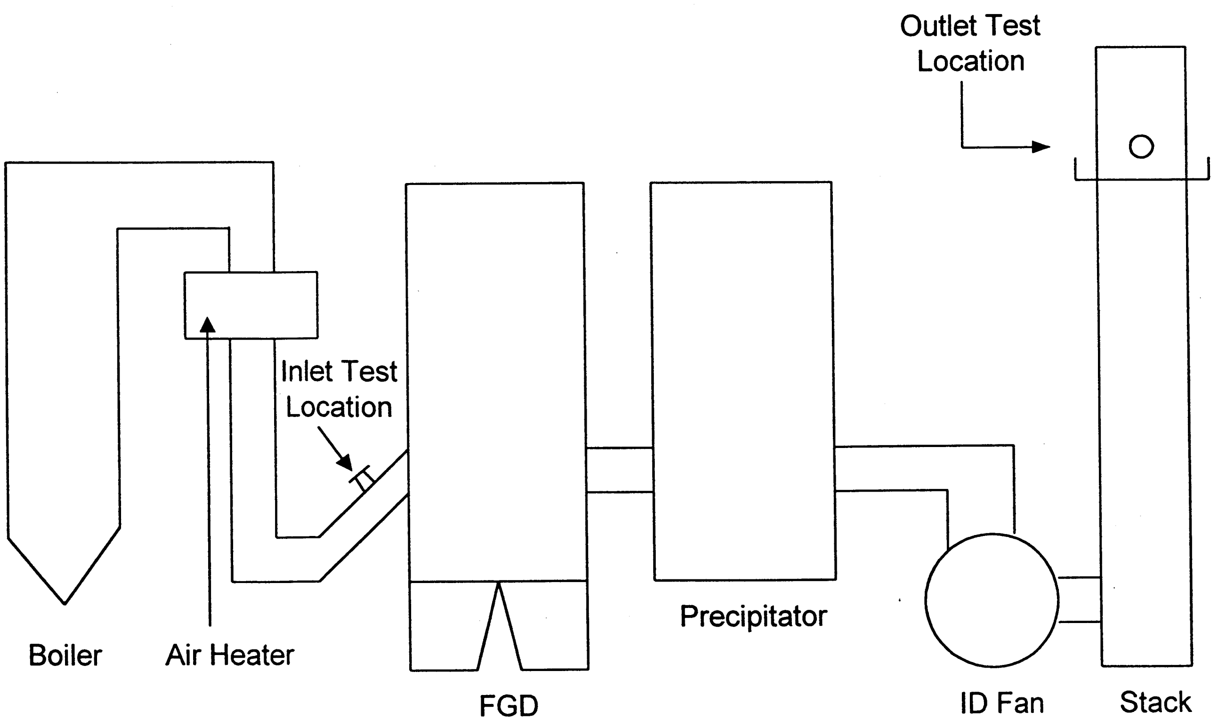
- Mostardi Platt Vice President, James Platt 630-993-9000
- Grand River Dam Authority, Doug Vore 918-476-5840

2.0 PLANT AND SAMPLING LOCATION DESCRIPTIONS

2.1 Process Description

Unit 2 is a pulverized coal-fired, balanced draft boiler rated at 520 MW (net). Figure 2-1 shows a schematic of the boiler and pollution control equipment, including sample points.

Figure 2-1 Schematic of the Boiler and Pollution Control Equipment



The following is a list of operating components for this unit:

- Foster Wheeler pulverized coal-fired balanced draft

- 520 MW gross capacity
- Fuel:
- – Wyoming (Subbituminous)
- – Oklahoma (Bituminous)

- SO_2 control - Dry FGD System

- NO_X control - Low NO_X burners and over fire air

- Flakt, Inc. - Electrostatic precipitator system with a 99.9% removal efficiency

2.2 Control Equipment Description

Sulfur dioxide (SO_2) emissions are controlled by a Flakt, Inc. dry flue gas desulfurization system with four (4) dryer reactors. The FGD is designed to remove 70% of the inlet SO_2. The FGD is followed by a Flakt, Inc. four (4) module electrostatic precipitator which is designed for a 99.9% particulate control efficiency.

The flue gas at the inlet was approximately 310°F. At the outlet (stack), the gas temperature is approximately 180°F and contains approximately 14 percent (14%) moisture.

2.3 Flue Gas Sampling Locations

2.3.1 Inlet Location

Inlet samples were collected at the FGD system inlet. A schematic and cross section of the inlet location are shown in Figure 2-2. This location does not meet the requirements of USEPA Method 1.

The inlet test location has 16 test ports. Eight (8) of the ports were traversed for flow and five (5) were traversed for mercury concentrations utilizing a ten (10) foot glass lined probe. Method 17 was used.

2.3.2 Outlet Location

Outlet samples were collected at the outlet (stack) of the precipitator. A schematic and cross section of the stack location are shown in Figure 2-3. This location meets the requirements of USEPA Method 1.

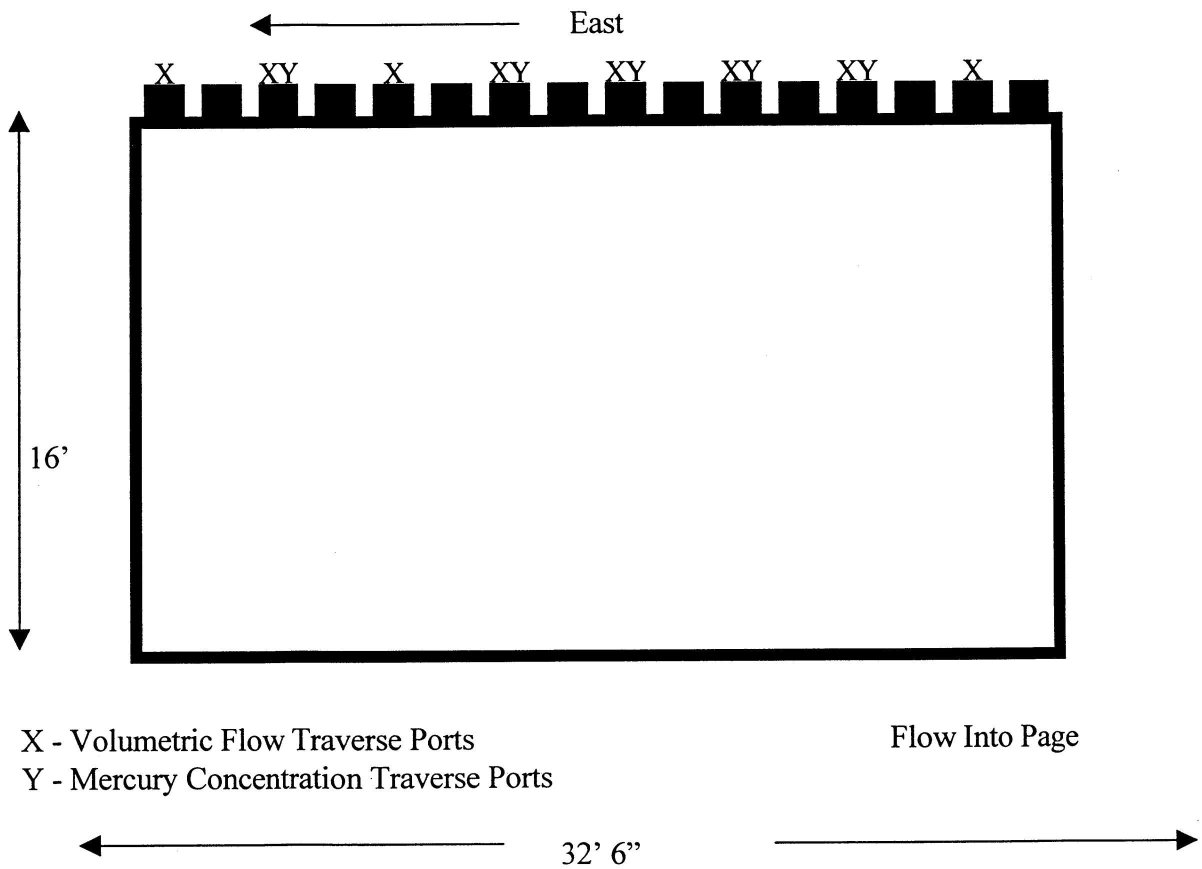
The flue gas at the stack was below the method specification of a minimum filtration temperature of 120°C. Therefore, the out of stack filtration per Method 5 was used.

2.4 Fuel Sampling Location

Coal samples were collected at the coal feeders to each individual pulverizing mills. One sample was collected from each feeder during each test run, and the feeder samples collected during a test run were composited prior to analysis.

Figure 2-2 Schematic of the FGD System Inlet Sampling Location

Equal Area Traverse For Rectangular Ducts (Inlet)

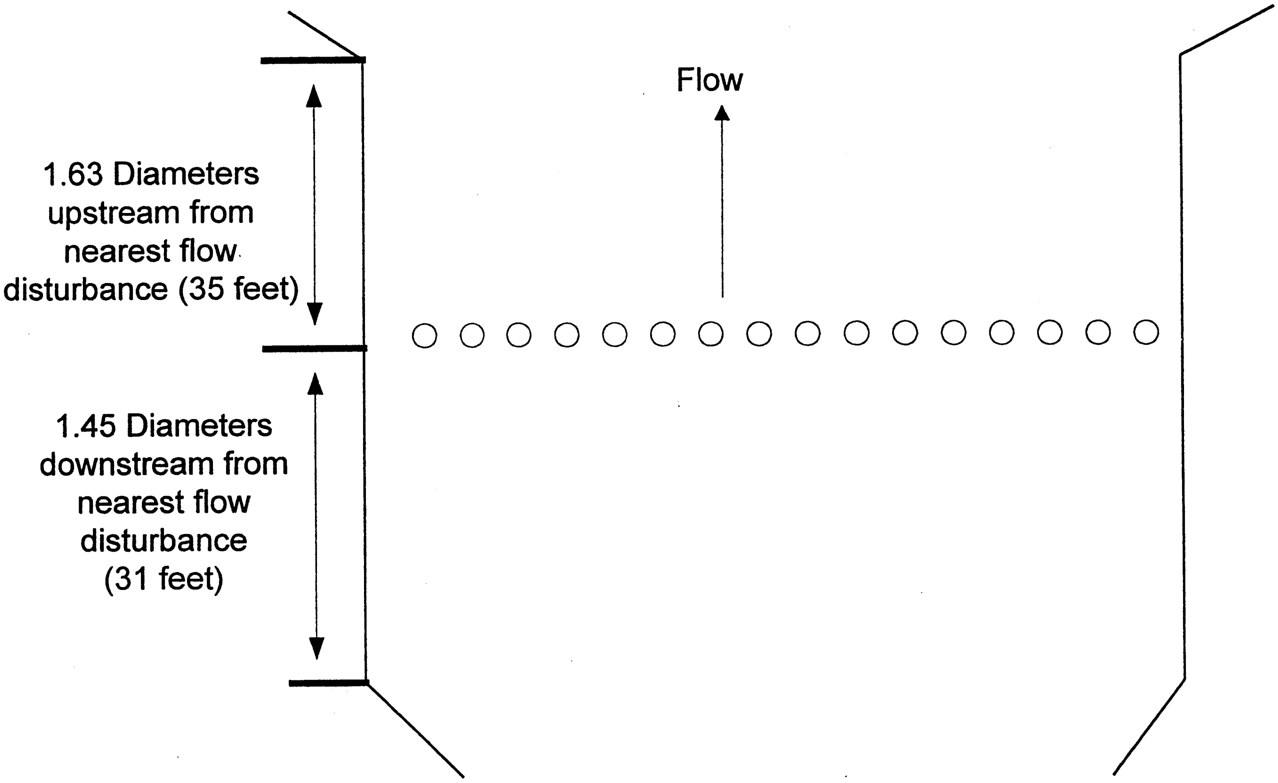


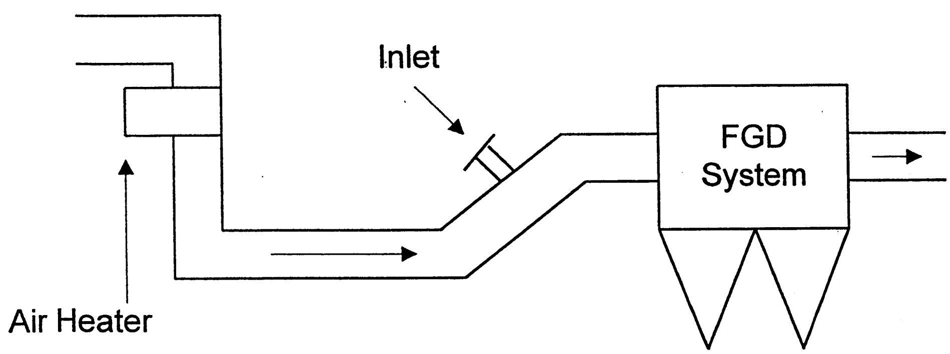
X - Volumetric Flow Traverse Ports
Y - Mercury Concentration Traverse Ports

Flow Into Page

Job:	Grand River Dam Authority Chouteau, Oklahoma		
Date:	September 22, 1999	Area:	520.00 ft^2
Unit No:	2	No. Test Ports:	16*
Length:	16 feet	Tests Points per Port:	5
Width:	32 feet, 6 inches	Distance Between Ports:	2.03 feet
Duct No:	FGD System Inlet	Distance Between Points:	

* Sixteen (16) test ports exist. Eight (8) were traversed for gas volumetric flow and five (5) were traversed for mercury concentrations. A 10-foot probe was utilized for the mercury sampling.





D = Equivalent Diameter

$$D = \frac{2 \times L \times W}{L + W}$$

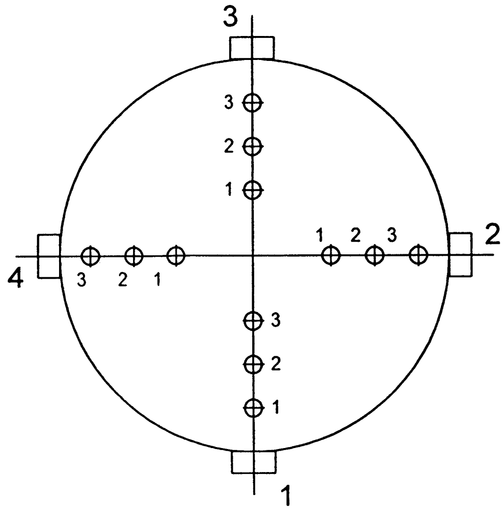
$$D = \frac{2 \times 16 \times 32.5}{16 + 32.5}$$

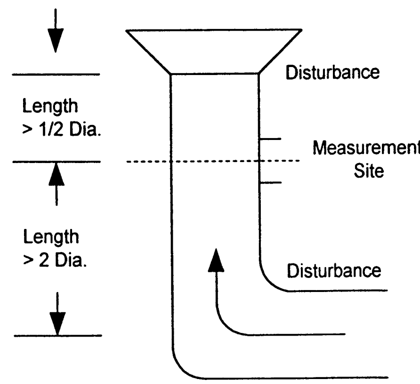
$$D = 21.4$$

Not to Scale

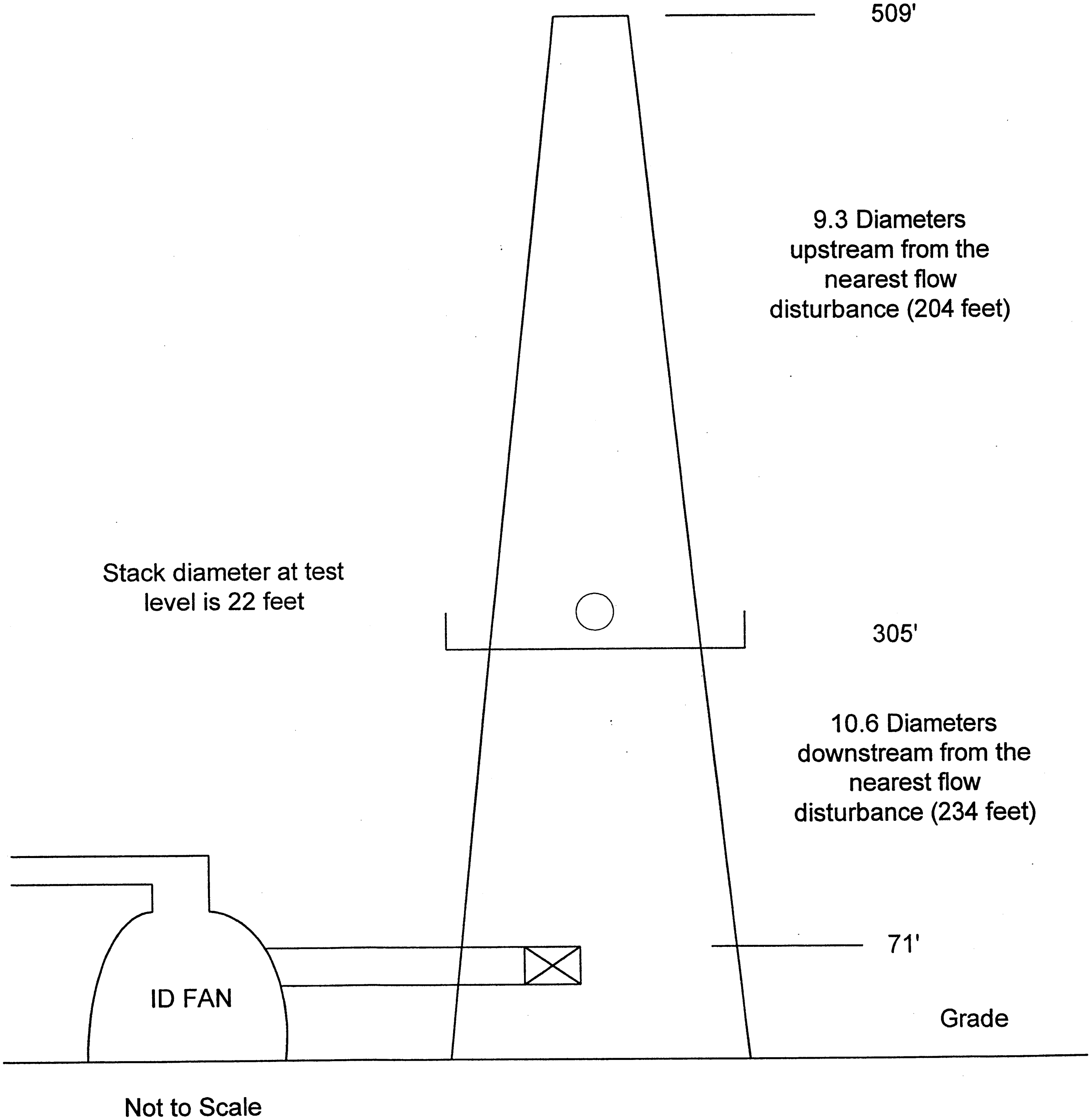
Figure 2-3 Schematic of the Stack Sampling Location

Equal Area Traverse for Round Ducts (Outlet)





Job:	Grand River Dam Authority Chouteau, Oklahoma		
Date:	September 22, 1999	Area:	380.133 ft^2
Unit No:	2	No. Test Ports:	4
Diameter:	22 Feet	Tests Points per Port:	3
Location:	Stack		


509'
9.3 Diameters upstream from the nearest flow disturbance (204 feet)
Stack diameter at test level is 22 feet
305'
10.6 Diameters downstream from the nearest flow disturbance (234 feet)
71'
ID FAN
Grade
Not to Scale

3.0 SUMMARY AND DISCUSSION OF TEST RESULTS

3.1 Objectives and Test Matrix

The purpose of the test program was to quantify mercury emissions from this unit. This information will assist the USEPA Administrator in determining whether it is appropriate and necessary to regulate emissions of Hazardous Air Pollutants (HAPs) from electric utility steam generating units. The specific objectives, in order of priority were:

- Compare mass flow rates of mercury at the three sampling locations (fuel, FGD System Inlet and Stack).
- Measure speciated mercury emissions at the outlet.
- Measure speciated mercury concentrations at the inlet of the last air pollution control device.
- Measure mercury and chlorine content from the fuel being used during the testing.
- Measure the oxygen and carbon dioxide concentrations at the inlet and the outlet.
- Measure the volumetric gas flow at the inlet and the outlet.
- Measure the moisture content of the flue gas at the inlet and the outlet.
- Provide the above information to the USEPA for use in establishing mercury emission factors for this type of unit.

The test matrix is presented in Table 3-1. The table shows the testing performed at each location, methodologies employed and responsible organization.

Table 3-1
TEST MATRIX FOR THE GRDA - CHOUTEAU, OKLAHOMA PLANT

Sampling Location	No. of Runs	Parameters	Sampling Method	Sample Run Time (min)	Analytical Method	Analytical Laboratory
Outlet	3	Speciated Hg	Ontario Hydro	120	EPA SW846 7470	TEI
Outlet	3	Moisture	EPA 4	120	Gravimetric	Mostardi Platt
Outlet	3	Flow	EPA 1 & 2	120	Pitot Traverse	Mostardi Platt
Outlet	3	O_2/CO_2	EPA 3	120	Orsat	Mostardi Platt
Inlet	3	Speciated Hg	Ontario Hydro	120	EPA SW846 7470	TEI
Inlet	3	Moisture	EPA 4	120	Gravimetric	Mostardi Platt
Inlet	3	Flow	EPA 1 & 2	120	Pitot Traverse	Mostardi Platt
Inlet	3	O_2/CO_2	EPA 3	120	Orsat	Mostardi Platt
Fuel Feeders	3	Hg, Cl in Fuel	Grab	1 Sample Per Feeder Per Run	ASTM D3684 (Hg) ASTM D4208 (Cl)	CTE

3.2 Field Test Changes and Problems

There were no field test changes or problems encountered during this test program.

3.3 Presentation of Results

3.3.1 Mercury Mass Flow Rates

The mass flow rates of mercury determined at each sample location are presented in Table 3-2.

Table 3-2
SUMMARY OF RESULTS

Sample Location	Elemental Mercury (lb/hr)	Oxidized Mercury (lb/hr)	Particle-Bound Mercury (lb/hr)	Total Mercury (lb/hr)
<u>Fuel</u>				
Run 1				0.04233
Run 2				0.04064
Run 3				0.04667
Average				**0.04322**
<u>FGD System Inlet</u>				
Run 1	0.02930	0.01667	0.00094	0.04691
Run 2	0.02461	0.01123	0.00200	0.03785
Run 3	0.01415	0.03350	0.00435	0.05200
Average	**0.02269**	**0.02047**	**0.00243**	**0.04558**
<u>Stack</u>				
Run 1	0.04027	0.00556	0.00003	0.04586
Run 2	0.03991	0.00458	0.00007	0.04457
Run 3	0.03837	0.00123	0.00003	0.03963
Average	**0.03952**	**0.00379**	**0.00004**	**0.04335**

3.3.2 Comparison of Volumetric Flow Rate

Volumetric flow rate is a critical factor in calculating mass flow rates. Ideally, the volumetric flow rate (corrected to standard pressure and temperature) measured at the inlet to the control device should be the same as that measured at the stack, which should be the same as that measured by the CEMS. Table 3-3 lists the comparison of flow rates of the three locations on a thousand standard cubic foot per minute basis (KSCFM).

Table 3-3 COMPARISON OF VOLUMETRIC FLOW RATE DATA							
	Inlet			Stack			CEMS
Run No.	KACFM	KSCFM	KDSCFM	KACFM	KSCFM	KDSCFM	KSCFM
Run 1	1882.1	1208.7	1056.6	1707.3	1380.5	1162.3	1549.2
Run 2	1892.3	1209.4	1068.3	1736.2	1403.1	1181.9	1577.4
Run 3	1900.2	1216.7	1064.3	1701.3	1375.2	1159.5	1440.3
Average	1891.5	1211.6	1063.0	1715.0	1386.3	1167.9	1522.3

The measured volumetric flow rate (KSCFM) at the inlet was approximately 13% lower than that measured at the outlet. The difference of the measured flow rate (KSCFM) at the outlet was within 9% of that determined by the continuous emissions monitoring system (CEMS). Because the inlet location did not meet the requirements of USEPA Method 1, the outlet volumetric flow rates were used to determine the emission rates at the inlet.

3.3.3 Individual Run Results

A detailed summary of results for each sample run at the FGD system inlet and stack are presented in Tables 3-4 and 3-5, respectively.

3.3.4 Process Operating Data

The process operating data collected during the tests is included in Appendix A. A summary of the coal usage and mass emission rate of mercury available from coal are presented in Table 3-6.

Table 3-4
FGD SYSTEM INLET INDIVIDUAL RUN RESULTS

Test Run Number:	**1**	**2**	**3**	**Average**
Source Condition		Normal		
Fuel Factor, dscf/10^6 Btu	9808	9903	10011	
Date	9/22/99	9/22/99	9/22/99	
Start Time	9:30	12:45	16:22	
End Time	11:29	15:11	18:34	
Elemental Mercury:				
ug detected	13.281	13.003	4.306	10.197
ug/dscm	6.73	5.56	3.26	5.18
lb/hr	0.02663	0.02225	0.01299	0.02062
lb/hr (based on outlet dscfm)	0.02930	0.02461	0.01415	0.02269
lb/10^{12} Btu	5.56	4.70	2.71	4.32
Oxidized Mercury:				
ug detected	7.555	5.935	10.195	7.895
ug/dscm	3.83	2.54	7.71	4.69
lb/hr	0.01515	0.01015	0.03075	0.01868
lb/hr (based on outlet dscfm)	0.01667	0.01123	0.03350	0.02047
lb/10^{12} Btu	3.16	2.14	6.42	3.91
Particle-bound Mercury:				
ug detected	<0.429	1.059	1.323	1.191
ug/dscm	0.22	0.45	0.45	0.37
lb/hr	0.00086	0.00181	0.00399	0.00222
lb/hr (based on outlet dscfm)	0.00094	0.00200	0.00435	0.00243
lb/10^{12} Btu	0.18	0.38	0.83	0.46
Total Inlet Speciated Mercury:				
ug/dscm	10.78	8.55	11.43	10.25
lb/hr	0.04264	0.03422	0.04772	0.04153
lb/hr (based on outlet dscfm)	0.04691	0.03785	0.05200	0.04558
lb/10^{12} Btu	8.89	7.22	9.96	8.69
Average Gas Volumetric Flow Rate:				
@ Flue Conditions, acfm	1,882,095	1,892,319	1,900,220	1,891,544
@ Standard Conditions, dscfm	1,056,568	1,068,265	1,064,250	1,063,027
Average Gas Temperature, ^oF	310.6	313.9	312.4	312.3
Average Gas Velocity, ft/sec	60.32	60.65	60.90	60.63
Flue Gas Moisture, percent by volume	12.59	11.67	12.53	12.26
Average Flue Pressure, in. Hg	28.04	28.03	28.03	
Barometric Pressure, in. Hg	29.44	29.44	29.44	
Average %CO_2 by volume, dry basis	13.2	13.0	13.0	13.1
Average %O_2 by volume, dry basis	5.4	5.6	5.2	5.4
% Excess Air	33.56	35.24	31.72	33.51
Dry Molecular Wt. of Gas, lb/lb-mole	30.328	30.304	30.288	
Gas Sample Volume, dscf	69.683	82.574	46.671	
Isokinetic Variance	99.3	102.4	103.3	

Table 3-5
STACK INDIVIDUAL RUN RESULTS

Test Run Number:	1	2	3	Average
Source Condition	Normal			
Fuel Factor, dscf/10^6 Btu	9808	9903	10011	
Date	9/22/99	9/22/99	09/22/1999	
Start Time	9:30	12:45	16:15	
End Time	11:48	15:00	18:30	
Elemental Mercury:				
ug detected	<17.295	17.205	<16.595	<17.032
ug/dscm	9.25	9.02	8.84	9.03
lb/hr	0.04027	0.03991	0.03837	0.03952
lb/10^{12} Btu	8.00	8.03	7.90	7.98
Oxidized Mercury:				
ug detected	2.385	1.975	0.531	1.630
ug/dscm	1.28	1.04	0.28	0.87
lb/hr	0.00556	0.00458	0.00123	0.00379
lb/10^{12} Btu	1.10	0.92	0.25	0.76
Particle-bound Mercury:				
ug detected	<0.018	<0.035	<0.016	<0.023
ug/dscm	0.01	0.02	0.01	0.01
lb/hr	0.00003	0.00007	0.00003	0.00004
lb/10^{12} Btu	0.01	0.01	0.01	0.01
Total Outlet Speciated Mercury:				
ug/dscm	10.54	10.07	9.13	9.91
lb/hr	0.04586	0.04457	0.03963	0.04335
lb/10^{12} Btu	9.11	8.97	8.16	8.75
Average Gas Volumetric Flow Rate:				
@ Flue Conditions, acfm	1,707,338	1,736,190	1,701,341	1,714,956
@ Standard Conditions, dscfm	1,162,265	1,181,853	1,159,540	1,167,886
Average Gas Temperature, °F	183.2	183.6	183.5	183.4
Average Gas Velocity, ft/sec	74.86	76.12	74.59	75.19
Flue Gas Moisture, percent by volume	15.81	15.77	15.68	15.75
Average Flue Pressure, in. Hg	29.47	29.47	29.47	
Barometric Pressure, in. Hg	29.51	29.51	29.51	
Average %CO_2 by volume, dry basis	12.5	12.7	12.7	12.6
Average %O_2 by volume, dry basis	6.1	6.4	6.3	6.3
% Excess Air	39.64	42.79	41.77	41.40
Dry Molecular Wt. of Gas, lb/lb-mole	30.244	30.288	30.284	
Gas Sample Volume, dscf	65.943	67.375	66.247	
Isokinetic Variance	101.8	102.3	102.5	

Table 3-6
COAL USAGE RESULTS

Test Run Number:	**1**	**2**	**3**	**Average**
Source Condition	Normal			
Date	9/22/99	9/22/99	09/22/1999	
Start Time	9:30	12:45	16:15	
End Time	11:29	15:11	18:34	
Coal Properties:				
Carbon, % dry	70.16	71.16	71.30	70.87
Hydrogen, % dry	4.84	4.86	4.81	4.84
Nitrogen, % dry	1.10	1.15	1.14	1.13
Sulfur, % dry	0.71	0.73	0.88	0.77
Ash, % dry	8.11	8.04	8.46	8.20
Oxygen, % dry (by difference)	15.08	14.06	13.41	14.18
Volatile, % dry	40.23	40.02	39.66	39.97
Moisture, %	24.16	24.90	24.25	24.44
Heat Content, Btu/lb dry basis	12091	12186	12096	12124
F_d Factor O_2 basis, dscf/10^6 Btu	9808	9903	10011	9907
F_c Factor CO_2 basis, scf/10^6 Btu	1863	1874	1892	1876
Chloride, ug/g dry	379.0	386.0	431.0	398.7
Mercury, ug/g dry	0.10	0.10	0.10	0.10
Coal Consumption:				
Wyoming Coal, Hlbs/test	10459	10132	11550	
Oklahoma Coal, Hlbs/test	705	691	773	
Total Raw Coal Input, Hlbs/hr	5582	5412	6162	5718
Total Coal Input, lbs/hr dry	423339	406404	466734	432159
Total Mercury Available in Coal:				
Mercury, lbs/hr	0.04233	0.04064	0.04667	0.04322
Mercury, lbs/10^{12} Btu	8.27	8.21	8.27	8.25

4.0 SAMPLING AND ANALYTICAL PROCEDURES

4.1 Test Methods

4.1.1 Speciated mercury emissions

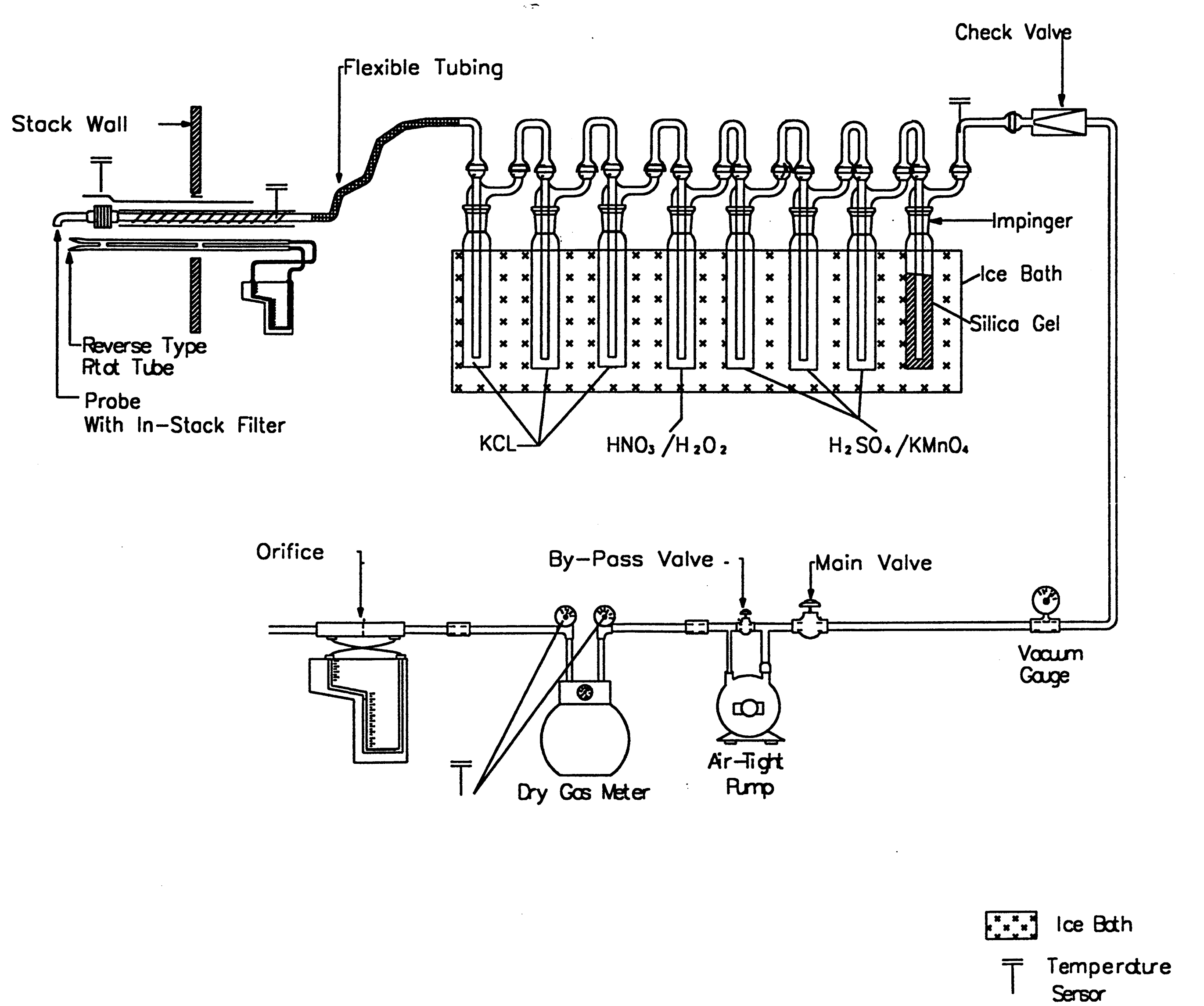
Speciated mercury emissions were determined via the draft "Standard Test Method for Elemental, Particle-Bound, and Total Mercury in Flue Gas Generated from Coal-Fired Stationary Sources (Ontario-Hydro Method)", dated April 8, 1999. Any revisions to this test method issued after April 8, 1999, but before July 1, 1999, were incorporated.

The in-stack filtration (Method 17) configuration was utilized at the FGD System Inlet test location. The out-of-stack filtration (Method 5) configuration was utilized at the Stack test location. Figures 4-1 and 4-2 are schematics of the Ontario-Hydro sampling trains.

Figure 4-3 illustrates the sample recovery procedure. The analytical scheme was per Section 13.3 of the Ontario-Hydro Method.

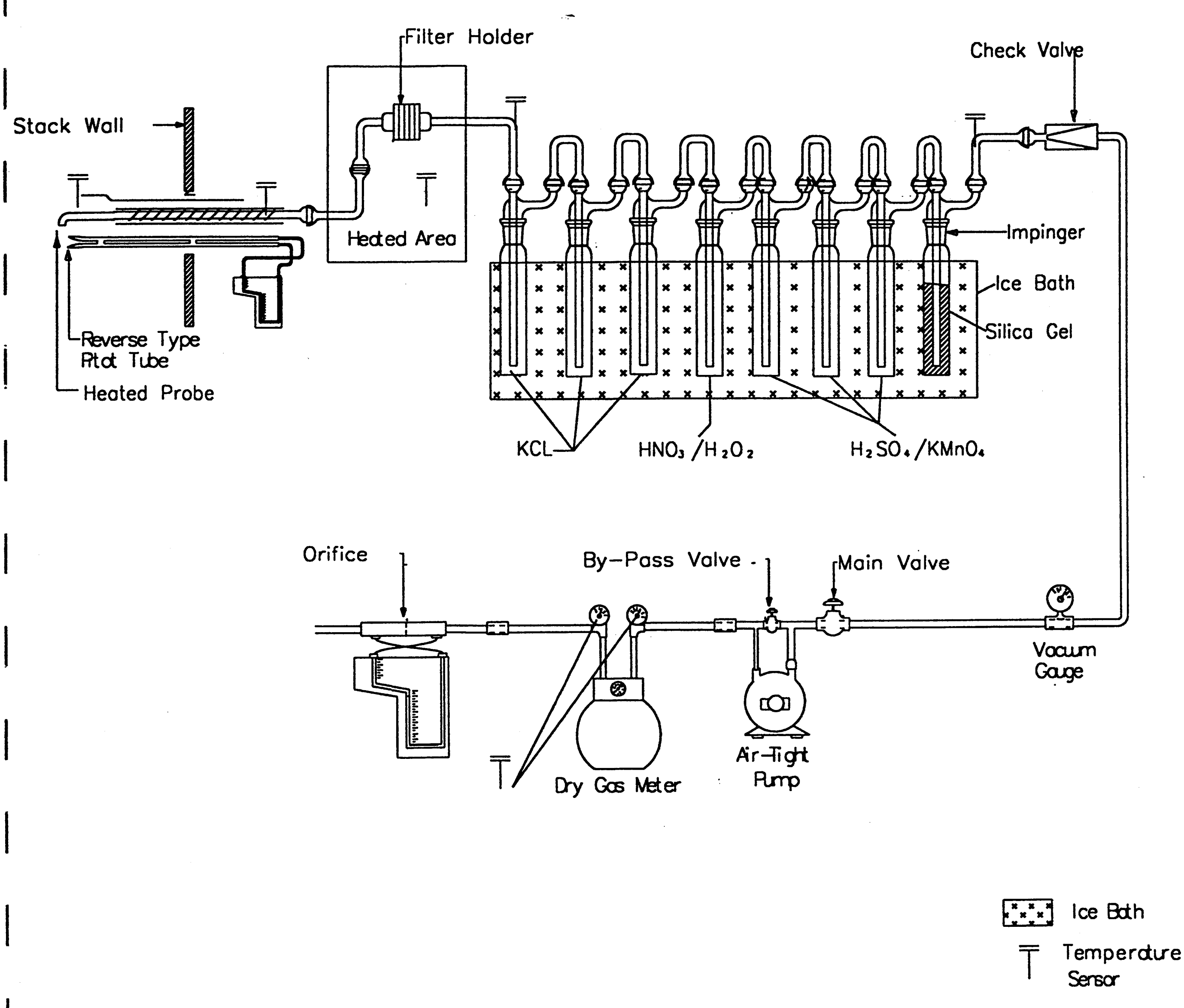
Speciated Mercury Sampling Train Equipped with In-Stack Filter

Ontario Hydro Method



Speciated Mercury Sampling Train Equipped with Out-of-Stack Filter

Ontario Hydro Method



Mostardi Platt

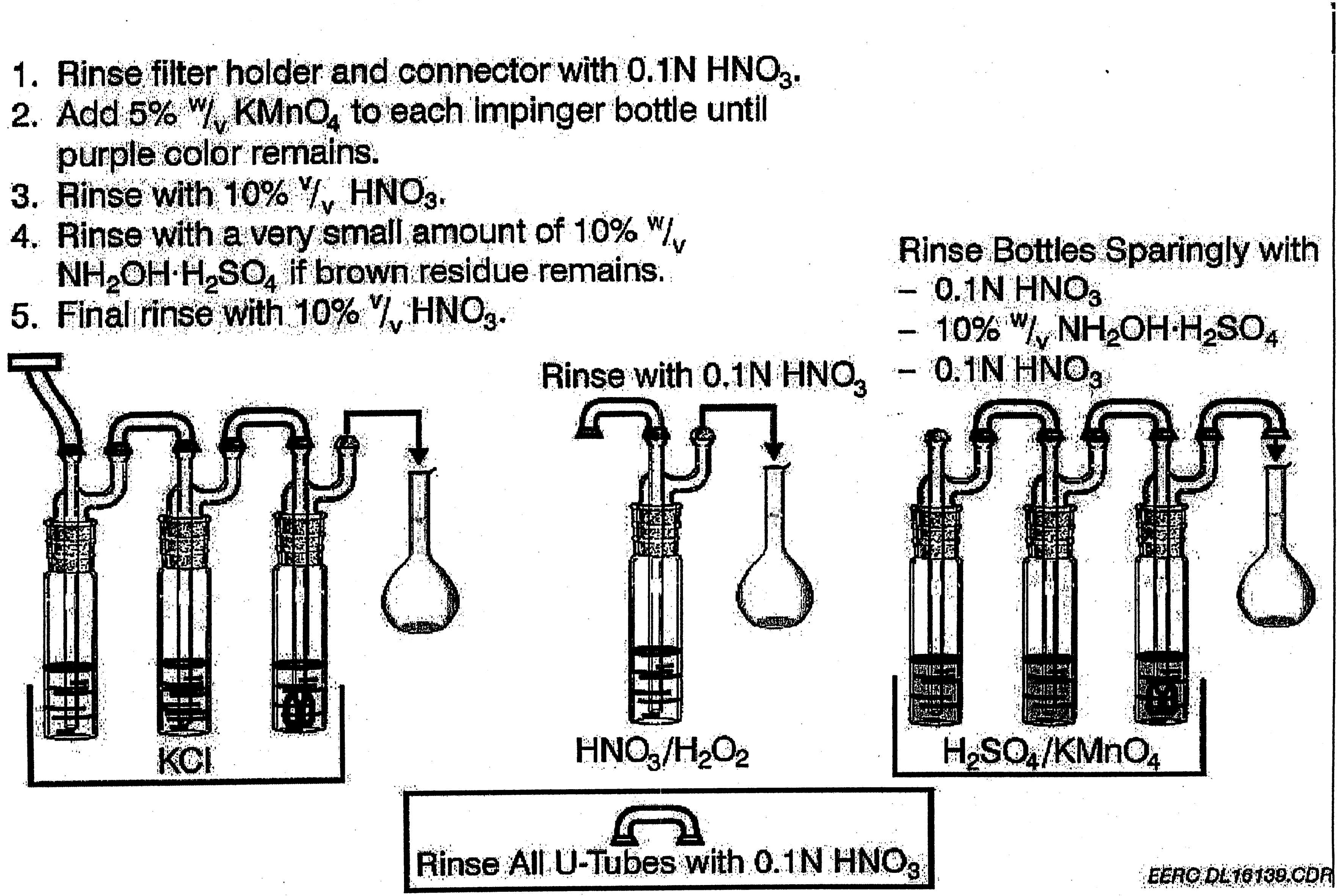


Figure 4-3: Sample Recovery Scheme for Ontario-Hydro Method Samples

4.1.2 Fuel samples

Fuel samples were collected by composite sampling. Samples were collected at coal feeders to each pulverizing mill during each speciated mercury sampling run. One sample was collected from each feeder during each test run and composited for analysis. Sample analysis was conducted according to the procedures of ASTM D3684 and ASTM D4208.

4.2 Procedures for Obtaining Process Data

Plant personnel were responsible for obtaining process-operating data. The process data presented in Table 3-6 was continuously monitored by the facility. Process data was averaged over the course of each sample run.

4.3 Sample Identification and Custody

The chain-of-custody for all samples obtained for analysis can be found in Appendix E.

5.0 INTERNAL QA/QC ACTIVITIES

All sampling, recovery and analytical procedures conform to those described in the site specific test plan. The precision and accuracy related to the speciated fractions are given in Appendix F. The accuracy of the results is given as CPI (recovery of an independent standard obtained from CPI) and the precision of the results is given as %RSD (relative standard deviation). All resultant data was reviewed by the laboratory and Mostardi Platt per the requirements listed in the QAPP and were determined to be valid except where noted below.

5.1 QA/QC Problems

Reagent blanks are required to be less than ten times the detection limit or ten percent of the sample values found.

The reagent blank, Sample ID #041, for $KMNO_4/H_2SO_4$ was found to be 0.078μg which is more than ten times the detection limit of 0.003 μg. This value was however, less than ten percent of the results for the $KMNO_4/H_2SO_4$ impingers and therefore the data does not need to be qualified.

The train blank value for the KC1 impinger at the outlet, Sample ID #028, was more than 30% of the values obtained at this location for the KC1 fraction. Procedural problems are outlined by the laboratory (see Appendix F) resulted in incorrect values being obtained initially for the KC1 fraction. These samples were reprepped and rerun with similar results being obtained.

5.2 QA Audits

5.2.1 Reagent Blanks

As required by the method, blanks were collected for all reagents utilized. The results of reagent blank analysis are presented in Table 5-1.

Table 5-1
REAGENT BLANK ANALYSIS

Sample ID	Sample Fraction	Contents	Mercury (µg)	Detection Limit (µg)
037	Front-half	0.1N HNO_3/Filter	< 0.002	0.002
038	1 N KCl	1 N KCl	0.005	0.003
039	*HNO_3/H_2O_2	HNO_3/H_2O_2	0.029 (0.026)	0.008
040, 041	$KMnO_4/H_2SO_4$	$KMnO_4/H_2SO_4$	0.045	0.003

* The result for the HNO/H_2O_2 blank was greater than 10% of the lowest test result for that fraction. Consequently, 0.026 g was used as the blank for all calculations involving the HNO_3/H_2O_2 fraction.

5.2.2 Blank Trains

As required by the method, blank trains were collected at both the inlet and stack sampling locations. These trains were collected on September 22, 1999. The results of blank train analysis are presented in Table 5-2.

Table 5-2
BLANK TRAIN ANALYSIS

Container #	Sample Fraction	Contents	Mercury (µg)	Detection Limit (µg)
031, 032, 033	Front-half	Filter	0.053	0.005
034, 035, 036	Front-half	Filter	< 0.005	0.005
025	KCl impingers	Impingers/rinse	1.72	0.03
028	KCl impingers	Impingers/rinse	4.87	0.03
026	HNO_3-H_2O_2 impingers	Impingers/rinse	< 0.04	0.04
029	HNO_3-H_2O_2 impingers	Impingers/rinse	< 0.04	0.04
027	$KMnO_4/H_2SO_4$ impingers	Impingers/rinse	0.318	0.03
030	$KMnO_4/H_2SO_4$ impingers	Impingers/rinse	0.359	0.03

5.2.3 Field Dry Test Meter Audit

The field dry test meter audit described in Section 4.4.1 of Method 5 was completed prior to the test. The results of the audit are presented in Appendix C.

